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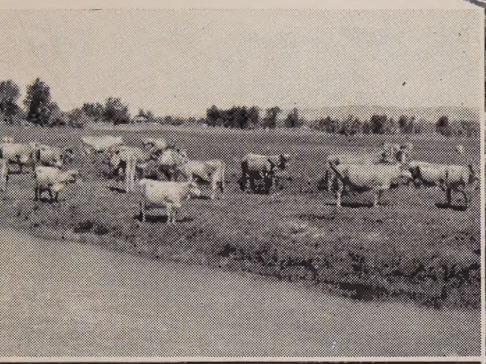
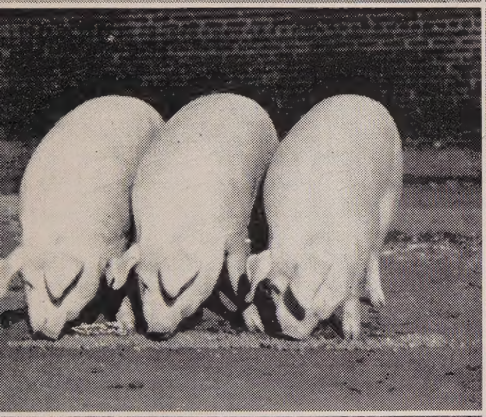
Minerals For Livestock

W. M. Beeson, F. C. Fountaine, and C. E. Lampman





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Minerals For Livestock

W. M. Beeson, F. C. Fountaine, and C. E. Lampman*

Introduction

MINERAL starvation limits the production and lowers the vitality of farm animals. Nearly every process of the animal body is dependent on one or more mineral elements for proper functioning, and the growth processes are so interrelated that the improper nourishment of any one part may exert a harmful effect on the entire animal. Mineral elements are just as essential for efficient growth, reproduction, and lactation as proteins, fats, carbohydrates, and vitamins. Intensified agriculture coupled with faster growing and higher producing livestock has made it necessary to focus more attention on balancing the mineral content of rations.

It has been established that the following mineral elements are essential in animal nutrition: calcium, phosphorus, sodium, chlorine, iron, copper, iodine, potassium, magnesium, manganese, cobalt, zinc, and sulphur. However, the only minerals which are of practical concern to Idaho farmers are: salt (sodium-chloride), calcium, phosphorus, iodine, iron, copper and in some instances manganese. The importance of supplying adequate amounts of minerals through feeding the right combination of feeds and supplying the specific minerals needed when necessary cannot be overemphasized. Use should be made only of those minerals which are absolutely essential. Furthermore, it should be emphasized that the indiscriminate feeding of mineral supplements is not recommended, either from the standpoint of good nutrition or economy in livestock production. Proper feeding and the economical production of livestock require the use of only those mineral supplements for which there is a specific need. This bulletin should serve as a guide to the kinds and amounts of minerals to feed to various types of livestock.

Dairy Cattle

The mineral requirements of dairy cattle generally are higher than for other livestock. Milk is rich in minerals; therefore, the feed for dairy cows must furnish the minerals necessary for milk production, as well as maintenance, growth, and reproduction. Heavy producing cows have a greater mineral requirement than low or average producers. A marked deficiency of minerals, especially of salt and phosphorus, will cause a reduction in milk yield. Where deficiencies occur, Idaho feeds are most likely to be lacking in sufficient salt, phosphorus, and iodine.

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Salt

Natural feeds do not supply enough salt to meet the requirements of dairy cattle. Salt must be supplied to dairy cattle at all times. A deficiency of salt in the diet will cause the cattle to show signs of salt craving; they will become run down in condition and will suffer a reduction in milk yield. Extreme deficiencies may cause an interference with normal calving. The average dairy cow needs ¾ ounce salt daily per 1000 pounds live weight, and in addition requires 3/10 ounce salt for every 10 pounds of milk produced. The salt requirement may be met by allowing the cattle free access to granulated salt and by mixing 1 per cent of salt in the grain mixture. It is recommended that a salt box be provided in a sheltered place in the exercise yard or pasture. Dairy cattle should have access to salt at all times, even when it is supplied in the grain mixture. Block salt is not recommended for dairy cattle.

Calcium

Because of the large amount of alfalfa hay available, cattle in Idaho seldom exhibit symptoms of calcium deficiency. A milk deficiency may occur when cattle are fed heavily on straw, beet tops, corn silage, corn stover, or any other nonlegume roughage. Cattle that are fed nonlegumes grown on a poor-producing, acid soil may show mild symptoms of calcium deficiency.

Symptoms of severe calcium deficiency are brittle bones, swollen joints, stiffness and lameness, and rickets in calves. These symptoms will seldom be observed under most Idaho conditions.

Rations built around good quality alfalfa hay provide sufficient calcium to meet the ordinary needs of dairy cattle. If a calcium deficiency is suspected or if the cattle are fed large amounts of nonlegume roughage, the ration may be fortified by the addition of ground limestone or ground oystershell. This may be provided by furnishing it in a box in a sheltered place in the exercise yard or pasture, and allowing the cattle free access to it, or by mixing 1 per cent of limestone in the grain mixture. Wet and dry beet pulp are good sources of calcium.

Phosphorus

A phosphorus deficiency frequently may occur in the dairy cattle of Idaho. This is especially true when wet beet pulp, molasses, or beet tops are fed. Phosphorus deficiency is characterized by loss in appetite, reduced milk production, a depraved or abnormal appetite for bones, sticks, dirt, and other unnatural substances, rough hair, creaking of joints in movement, and general unthrifty appearance.

All grains and seeds, grain by-products, especially wheat bran, and protein concentrates are good sources of phosphorus. Alfalfa hay and pasture are fair sources of phosphorus when grown on soil that contains adequate available phosphorus. Certain areas in Idaho

have phosphorus deficient soil. Cattle in these areas are likely to show symptoms of phosphorus deficiency unless phosphorus supplements are added to their ration. Cattle that are fed rations made up of good quality legume hay supplemented by a grain concentrate usually receive adequate phosphorus for their needs. However, cattle that are fed solely on alfalfa hay or that are fed beet pulp or molasses usually need an additional source of phosphorus.

Additional phosphorus may be supplied by feeding steamed bonemeal. To be assured that the product is palatable, only odorless steamed bonemeal should be used. If it can be secured, odorless steamed bone flour is recommended. When the cattle are fed a concentrate, bonemeal may be supplied by mixing 2 per cent in the grain mixture. When cattle are fed solely on alfalfa hay, they should be allowed free access to a mineral mixture of 2 parts of steamed bonemeal and 1 part of salt. When used, this mixture should be furnished in addition to salt. A cow should not be required to eat bonemeal to satisfy her desire for salt. A box for the bonemeal-salt mixture may be located conveniently next to the salt box. It is recommended that dry cows be given free access to this mixture.

Because of its toxic flourine content, raw rock phosphate should not be fed. If the flourine is removed, raw rock phosphate is suitable as a phosphorus supplement.

Iodine

Many Idaho feeds are deficient in iodine. Therefore, to prevent a deficiency, it is advisable to supply some source of iodine to dairy cattle. Symptoms of an iodine deficiency are characterized by goiter or big neck in calves at birth. Such calves are usually born dead, or live only a short time after birth. Failure of cows to settle, or difficulty in settling cows may result from an iodine deficiency.

Iodine is most easily fed in the form of iodized salt. Iodine is a very unstable element, and will be lost from the salt unless precautions are taken to stabilize it. A formula for a stable iodine salt mixture is given on page 8. Iodized salt is fed as recommended for common salt. It supplies both the salt and iodine needs of cattle.

Minor Elements

Minor elements such as iron, copper, magnesium, manganese, cobalt, and sulphur, are necessary for the growth, reproduction, and well-being of dairy cattle. Our present knowledge indicates that feeds grown in Idaho contain sufficient amounts of these minor elements to meet all the body needs of cattle. There is no advantage in supplying mineral supplements that carry these elements.

Several commercial mixtures generally are available to Idaho farmers. Their use depends on their composition, convenience, and relative cost compared to steamed bonemeal and iodized salt.

Dry Cows

The mineral requirements of dry cows should be given special

consideration. During the dry period the dairy cow replenishes the minerals lost from her body in the previous lactation and builds up body stores of minerals to be used in the lactation to follow.

It is recommended that the grain mixture for dry cows contain 2 per cent of steamed bonemeal. In addition it is desirable to allow the dry cows free access to a mixture of 2 parts of bonemeal and 1 part iodized salt. The dry cow also must have free access to salt.

Beef Cattle

Salt

Seldom are the salt requirements of cattle met by natural feeds and therefore it should be made available at all times. Symptoms of a salt deficiency are manifested by a marked salt hunger, depraved appetite, poor milk production and general emaciation. The salt requirement may be met by giving the cattle free access to either block or granulated salt in a suitable box or by mixing finely granulated salt as ½ per cent of the grain mixture. Cattle require about 20 pounds of salt per year under range conditions.

Calcium

A calcium deficiency seldom occurs in cattle under Idaho feeding conditions, because of the abundance of calcium-rich alfalfa hay. A deficiency may occur when cattle are wintered on marsh hay, corn stover, corn silage, straw, meadow hay, potatoes, beet tops or any nonlegume roughage.

Symptoms of a calcium deficiency are brittle bones, weak calves, stiffness in legs, swollen joints and rickets in young animals. Severe calcium deficiency results in paralysis and coma.

The calcium requirement may be satisfied as follows:

(1) Feeding 1 pound of alfalfa or other legume hay per 100 pounds of live weight;

(2) When cattle are fed principally on nonlegume roughages, either give them free access to a calcium supplement, or mix 1.0 per cent of the supplement in the grain mixture. For palatability it usually helps to mix two parts of calcium with one part of salt. One-tenth of a pound of ground limestone or oyster shell per steer or cow daily will be adequate.

Phosphorus

A phosphorus deficiency occurs quite often with beef cattle in Idaho because a number of our natural feeds such as molasses, beet pulp, and beet tops are deficient in phosphorus.

Symptoms of a phosphorus deficiency are shown by loss of appetite, poor condition, rough hair, chewing boards, bones, and other foreign material, and eating dirt. Steers on fattening rations low in phosphorus make very slow and inefficient gains, fail to fatten, and

in extreme cases death occurs. Inadequate phosphorus in the diet of breeding stock will cause irregular breeding and the production of weak calves.

Feeds which are low in phosphorus are molasses, wet or dried beet pulp, cereal straws, bean straw, pea straw, meadow grass hay, clover chaff, alfalfa chaff, and range plants that are fully matured. Cattle wintered for long periods on barley, oat, pea, bean or wheat straw or meadow hay may become deficient in phosphorus if the daily ration is made up of any one or a combination of these feeds. To correct this deficiency half of the low phosphorus roughage should be replaced with alfalfa hay or give the cows free access to a mineral mixture of 2 parts of bonemeal and 1 part of salt.

All grains, by-products of grains, protein concentrates, legume hays, and green pasture are good sources of phosphorus. Therefore, when rations of cattle are made up principally of these feeds, the phosphorus requirement usually is satisfied. When cattle are wintered on good quality alfalfa hay containing 0.15 per cent or more phosphorus, no additional source of phosphorus is needed. Alfalfa produced on soil that is low in available phosphorus many times contains less than 0.15 per cent phosphorus.

The phosphorus requirement for fattening cattle is about 2.0 grams of phosphorus daily per 100 pounds of live weight, and this requirement may be satisfied by feeding the following feeds or mixtures of feed daily per 100 pounds of live weight:

2.0 pounds of alfalfa hay per cwt.
1.0 pound wheat per cwt.
1.2 pounds barley per cwt.
0.03 pound steamed bonemeal per cwt.
1.0 pound of alfalfa hay plus 1.0 pound grain per cwt.
1.0 pound alfalfa hay plus 0.2 pound of cottonseed meal per cwt.
1.5 pounds of alfalfa hay plus 0.5 pound of grain per cwt.
1.0 pound of straw plus 0.025 pound of steamed bonemeal per cwt.

If phosphorus is the only food element lacking in the ration, it may be supplied economically by supplementing the grain mixture with ½ per cent of steamed bonemeal or allowing the cattle free access to a mineral mixture of 2 parts of steamed bonemeal and 1 part of salt. Cattle requiring additional phosphorus usually will supply their own needs if self-fed steamed bonemeal.

Raw rock phosphate should not be used as a phosphorus supplement for livestock because it contains toxic amounts of flourine. If the fluorine is removed rock phosphate is a suitable phosphorus supplement.

Iodine

Idaho is located in a borderline iodine deficient belt. Therefore, for best results it is advisable to supply some source of iodine to

breeding cattle. Iodine is necessary for the proper functioning of the thyroid gland which is instrumental in regulating the metabolic rate of the body. An iodine deficiency is characterized by enlarged neck or goiter in calves at birth. Calves with a goiterous condition are either born dead or if born alive the calf usually fails to survive. Failure of cows to settle or difficulty in settling cows may be due to an iodine deficiency.

Iodine is a very unstable compound and readily volatilizes from salt mixtures if stored for long periods. A stable iodine salt mixture, developed by the Wisconsin Experiment Station, is as follows:

	lb.
Sodium thiosulphate	2.0
Sodium carbonate	2.0
Cornstarch	2.0
Potassium iodide	0.4

Mix with 1 ton of finely ground salt. It is advisable to add a small amount of charcoal to color the iodine mixture so as to be able to detect when it is thoroughly mixed with the salt.

If an iodine mixture is made up every 2 to 3 months, it is satisfactory to use a mixture of 1 ounce of potassium iodide to every 300 pounds of salt. Iodized salt may be used provided it has not lost the iodine value. Iodine usually can be detected by the odor.

Minor Elements

Many minor mineral elements, a few of which are iron, copper, cobalt, magnesium, manganese, and sulphur are necessary for the growth and reproduction of cattle, but as far as is known the feeds raised in Idaho contain sufficient amounts of these minor elements to meet the body requirement. There is no advantage or need of feeding mineral elements that already are present in sufficient quantities in the diet. Many claims have been made that feeding sulphur prevents animals from being invested with ticks, but experimental evidence has not shown this to be a fact.

Sheep

Salt

Salt should be supplied to sheep at all times with either free access or mixed in as ½ per cent of the grain mixture. Fattening lambs will consume about ¼ ounce per head daily and breeding sheep may eat nearly ½ ounce per head daily. If sheep are deprived of salt for too long an interval, they will overeat, resulting in salt poisoning and death. Sheep that are grazed on abundant green forage or wintered on good quality alfalfa hay need no mineral supplement excepting salt and in some areas iodine.

Calcium

Under Idaho conditions sheep rations usually are adequate in calcium because of the universal use of alfalfa hay as the principal feed.

However, a calcium deficiency may occur in sheep under the following conditions:

(1) Pasturing on beet tops. Beet tops are high in oxalic acid and this compound interferes with the utilization of calcium. The production of weak and unthrifty lambs from ewes on beet tops usually is caused by a calcium deficiency.
(2) Feeding ewes on large amounts of potatoes, straw or nonlegume roughage may cause a calcium deficiency.
(3) Fattening sheep with grain and nonlegume roughages. In general a calcium supplement must be fed to sheep when the roughage consists only of nonleguminous plants.

Calcium deficiency usually is manifested by weak lambs and poor milk production, and occasionally premature lambs will be born. In the feed lot the lambs gain poorly and many times become extremely knock-kneed. The best indicator is to check on the ration being fed.

The calcium requirement of sheep may be satisfied as follows:

(1) When one-half of the roughage is good quality legume hay.
(2) By feeding 0.25 to 0.40 ounce of ground oyster shell or limestone per sheep daily.
(3) By giving the sheep free access to a mineral mixture of 2 parts of ground oyster shell or other supplement to 1 part of common salt by weight. A sheep requires about 0.25 per cent calcium in the ration.
(4) By providing good green pasture.

Phosphorus

A phosphorus deficiency may occur if pregnant or lactating ewes are wintered chiefly on wet pulp, potatoes, beet tops, nonlegume hay, dry range feed, or by the feeding of heavy amounts of beet molasses in conjunction with beet pulp. If lambs are fattened on large amounts of beet pulp and molasses and a limited amount of alfalfa hay, the ration will be low in phosphorus.

A phosphorus deficiency in sheep is characterized in lambs by slow gains, high feed requirement, lack of finish, listless appearance, narrow and leggy conformation, eating boards and dirt, and in many cases an extreme knock-kneed condition. In ewes milk production is poor and the lambs may be born weak or dead. In addition to the above symptoms the level of blood phosphorus is below normal (less than 4.0 mg/100ml.) in ewes and lambs on low phosphorus rations.

Idaho experiments have shown that a phosphorus deficiency is difficult to produce in lambs unless they are fed heavily on wet beet pulp and molasses and a limited amount of alfalfa hay. This research indicates that a lamb requires for optimum results a daily intake of about 2.40 grams of phosphorus per 100 pounds of live weight. Con-

verting these results to a practical feed basis, the phosphorus requirement of lambs may be met by feeding the following amounts of any of the feeds per lamb daily: 2.0 lb. alfalfa hay, 2.0 lb. clover hay, 1.0 lb. barley, 1.0 lb. wheat, 1.0 lb. of oats, 0.33 lb. of wheat bran or 0.03 lb. of steamed bonemeal. Good quality alfalfa hay contains about 1.0 gram of phosphorus per pound. Therefore, a sheep receiving 2.4 pounds of alfalfa hay per 100 pounds of live weight would receive ample phosphorus. A pregnant or lactating ewe will receive ample phosphorus if she is wintered on good quality alfalfa hay with some grain before and after lambing. **However, a phosphorus deficiency may occur in pregnant ewes if they are wintered on low phosphorus alfalfa hay (e. g. 0.15 per cent or less phosphorus). Ewes fed on low phosphorus alfalfa hay should be given free access to a mixture of equal parts of steamed bone meal and finely ground salt.**

Iodine

A deficiency of iodine often occurs in ewes and causes the production of weak lambs with enlarged necks. This goiterous condition is caused by the enlargement of the thyroid gland which secretes a hormone called thyroxine. Thyroxine regulates the rate of body metabolism and contains iodine. In districts where there is trouble with goiter from new born lambs, the ewes should be fed iodized salt at least during the last half of pregnancy (see page 8 for iodine mixtures).

Cobalt

A cobalt deficiency may occur in ewes and lambs in areas where there is a deficiency of this element in the forage plants. As yet no such area has been found in Idaho. A lack of cobalt causes an unthrifty, anemic, dried out, and listless appearance in sheep. The hemoglobin of the blood falls extremely low and is cured only by administering cobalt. A cobalt deficiency may be cured by adding 4 ounces of cobalt chloride to each ton of salt.

Other Minerals

Experimental evidence indicates that other mineral elements, including iron, copper, sulphur, potassium, magnesium, manganese, etc., need not be added to the usual rations of sheep. Sulphurized salt will not keep the ticks off of sheep.

Hogs

Salt

Hogs of all ages should have salt (sodium chloride) whether on pasture or in dry lot. Adequate amounts of salt may be supplied by including ¼ to ½ per cent of finely ground salt in the grain mixture, or by allowing the hogs free access to salt alone or mixed with minerals. Finely ground stock salt is preferable to mix in with the grain but coarsely ground or block salt may be used, where hogs are given free access to salt. It is rather difficult for hogs to secure enough salt from a block. Hogs that have been denied salt for some time and then given free access to it may eat such large quantities as to cause digestive disturbances and even death. Animals hungry

for salt should be given small quantities daily until the intense craving has largely disappeared.

Calcium

Calcium deficiency is so prevalent among hogs in Idaho that too much attention cannot be given to balancing swine rations in regard to this mineral. All grains, by-products of grains, and vegetable protein supplements are deficient in calcium. Hogs do not consume enough roughage in the form of legume hay to satisfy their calcium needs. It is imperative that all hog rations be supplemented with some source of calcium.

Symptoms of a calcium deficiency are characterized in fattening and growing pigs by going off feed, stiffness, buckled and enlarged joints, lameness, and posterior paralysis. Usually the fattest and fastest growing pigs succumb first due to the fact that their system requires more calcium for the development of the skeletal system. In extreme cases of calcium deficiency hogs die suddenly from a low-calcium tetany. Brood sows and gilts deprived of adequate calcium produce weak pigs and usually do not have sufficient milk to nourish the pigs. Poor milk production is one of the most characteristic symptoms of a calcium deficiency. In severe cases sows will break down in the back resulting in a posterior paralysis.

Calcium supplements usually are cheap and available in most communities. Flour-fine oyster shell, ground limestone, calcite, steamed bonemeal, marl gypsum, air slaked lime, calcium carbonate or wood ashes are all good calcium supplements.

All hog rations should be supplemented with calcium unless the diet is being balanced adequately with meat meal, fishmeal, skim milk, or buttermilk. However, even when animal proteins are used, it is a good practice to give the hogs free access to a calcium supplement.

Calcium supplements, such as ground oyster shell or others, should be added at the rate of 1 pound to 100 pounds of grain or, in other words, as 1 per cent of the grain mixture. The same results may be accomplished by allowing the hogs free access to one of the following mineral mixtures:

Mixture 1		Mixture 2	
Oyster shell	200 lb.	Oyster shell	100 lb.
Salt	100 lb.	Steamed bonemeal	100 lb.
Potassium iodide	1 oz.	Salt	100 lb.
		Potassium iodide	1 oz.

Phosphorus

A phosphorus supplement is never needed in a hog ration because all grains and by-products of grains are rich in phosphorus and adequately supply the body requirement. In fact, adding a phosphorus supplement tends to unbalance the ratio of calcium to phosphorus and thus upset the mineral balance.

Iodine

Many areas in Idaho are deficient in iodine, which makes it advisable to supply a source of iodine in brood sow and boar rations. An iodine deficiency easily is detected by the enlarged necks and hairless pigs at birth. Add 1 ounce of potassium iodide to each 300 pounds of finely ground salt, feed iodized salt, or use the Wisconsin formula suggested on page 8.

Iron and Copper

Suckling pigs confined to enclosures with concrete or wooden floors, or on frozen ground, so that the pigs do not have access to soil usually develop nutritional anemia in about 2 to 3 weeks after birth. Anemia is caused by a lack of sufficient iron and copper in the mother's milk, and since milk naturally is deficient in these mineral elements, the little pig must seek other sources to satisfy this nutritional requirement.

Symptoms of anemia usually appear 2 to 3 weeks after birth and are associated with pot bellies, rapid breathing and "thumping." Affected pigs are weak, listless, and extremely short of breath.

One of the most practical and successful ways to prevent anemia is to provide plenty of clean soil or green feed for the pigs to eat. Fresh soil (free from parasite eggs) should be placed in the pens at frequent intervals. Clean soil ordinarily contains sufficient iron and copper to supply this need. If the soil is deficient in iron and copper, it may be fortified by mixing 1 pound of ferrous sulphate (copperas) with 50 pounds of soil. Another treatment for anemia is to swab the sow's udder daily with a saturated solution of ferrous sulphate. As soon as the pigs start eating grain, special treatments for anemia may be discontinued.

It appears that the addition of excessive amounts of iron compounds to mineral mixtures is not necessary, and it usually interferes with the assimilation of phosphorus.

In areas where the soil and feeds are low in iron and copper, this condition may be corrected by allowing the hogs free access to the following mineral mixture:

	lb.
Salt (finely ground)	20.00
Oyster shell (flour fine)	40.00
Steamed bonemeal	37.95
Iron oxide	2.00
Copper sulphate	.03
Potassium iodide	.02
Total	100.00

Minor Elements

Other mineral elements, such as potassium, manganese, magnesium, cobalt, sulphur, zinc, etc., are distributed abundantly enough among natural feeds to satisfy the requirement of weanling and older pigs. Under certain feeding conditions manganese has been shown to be lacking in hog fattening rations, resulting in lameness and enlargement of hock joints. However, as far as is known, this deficiency does not exist in feeds used in Idaho. Calcium, salt, iodine, iron, and copper are the only minerals that need to be added to hog rations.

Horses and Mules

Horses or mules are not very susceptible to mineral deficiencies because they are slow growing and usually are fed in Idaho on good pasture or alfalfa hay. However, the soundness of bone and durability of the feet and legs can be enhanced materially by feeding rations properly balanced in minerals. Many unsoundnesses are produced by feeding a ration inadequate in minerals.

Salt

Horses and mules of all ages need common salt available at all times. During hot weather when horses are sweating profusely, a liberal allowance of granulated salt in addition to block salt will aid in preventing fatigue and overheating. Horses sweat out large quantities of salt when working in hot weather and this must be replaced by heavy salting.

Calcium and Phosphorus

Calcium and phosphorus are very important in building and maintaining sound bone. The growing colt and the pregnant mare have the highest demand for these minerals. Calcium and phosphorus may be amply supplied by feeding at least one-half of the roughage as alfalfa hay. If pregnant mares or growing horses are fed on nonlegume hay or straw, it would be advisable to give them free access to a mixture of 2 parts of steamed bonemeal and 1 part of salt by weight. As long as alfalfa hay is the principal horse feed no minerals other than iodized salt are needed.

Iodine

Idaho is in the goiter belt and, therefore, iodized salt or some other source of iodine should be made available to horses—especially foals, pregnant mares, and stallions. A home mixture may be made by using 1 ounce of potassium iodide in 300 pounds of salt (see discussion on page 8).

Poultry

The supplementary minerals concerned in rations for poultry include salt, calcium, phosphorus, and in some instances, manganese.

Salt

All classes of poultry require salt. It plays an important role in nutrition, is neccessary for normal body processes, and adds palatability to the ration. There is some evidence which indicates that a deficiency of salt may aggravate cannibalism. Fine granular salt, free from lumps, should be added to the ration at the rate of 1 per cent of a mash which is to be fed with grain or 0.5 per cent of an all-mash ration. An excess of salt is injurious—if any lumps are present the salt should be sifted through a small mesh wire such as fly screen.

Calcium

Any combination of grains, mill feeds, and the plant protein supplements are deficient in calcium until specifically supplemented with this important mineral. The utilization of calcium is intimately associated with that of phosphorus and is influenced by the adequacy of vitamin D or the ultraviolet rays of direct sunshine which function as calcifying agencies. It is necessary to have the calcium and phosphorus in proper amounts and in correct ratio to each other— approximately 2 parts of calcium to 1 of phosphorus. Laying hens have additional requirements for calcium in the form of calcium carbonate for shell formation.

Symptoms of calcium deficiency include leg weakness or rickets and crooked keels in the case of young chicks, thin-shelled eggs in the case of layers, and reduced hatchability of eggs in breeders.

The chick starter mash should contain 1.75 to 2.00 per cent calcium and the laying mash, 2.26 to 2.50 per cent. Supplementary calcium commonly is supplied by adding oyster shell, calcite, or limestone in the chick-sized granulation, or ground as flour, at the rate of 2 to 3 per cent of the mash. If limestone or calcite is used, the product should not contain more than 2 per cent magnesium carbonate. When liquid skim milk or the legume proteins are used to replace meat meal to any great extent, 4 per cent oyster shell may be required in the laying mash. Oyster shell flakes should be available in hoppers at all times for laying hens and for growing stock after 6 weeks of age. Bonemeal also supplies calcium in the form of tri-calcium phosphate.

Phosphorus

The need for supplementary phosphorus depends upon the type and source of protein, particularly the bone content of such animal proteins as the meat and fish meals and the extent to which liquid skim milk or the legume proteins are used. As previously stated, the utilization of phosphorus is linked closely with that of calcium and it is necessary to have the ratio kept in the proportion of approximately 2 parts of calcium to 1 of phosphorus.

An excess of these minerals, particularly phosphorus, is likely to aggravate the condition commonly known as perosis or "slipped tendons." The liberal use of meatmeal containing large amounts of bone is the most common cause of excess phosphorus. Young turkey poults seem to be especially sensitive to the calcium-phosphorus balance.

The phosphorus content of the starter mash for either chicks or poults should not be less than 0.7 per cent or more than 1.0 per cent. The laying mash should contain from 1 to 2 per cent. Phosphorus commonly is supplied by adding edible steamed bonemeal. When meat meal is the principal animal protein supplement no additional phosphorus in the form of bonemeal is required; however, if skim milk, peas, or soybean oil meal are used extensively, bonemeal will need to be added at the rate of 1 to 2 per cent of the mash. The provision of phosphorus in the correct amount is best safeguarded by always using a proved formula.

Manganese

A deficiency in manganese may occur when birds are kept in confinement and when the rations are low in content of wheat bran or shorts or if calcite is used instead of oyster shell.

Insufficient manganese results in (1) "enlarged hocks" or "slipped tendons" (more technically known as perosis) in young chicks or poults; (2) thin, weak egg shells in the case of layers; and (3) poor hatchability and deformed embryos in the case of breeders. Perosis in growing stock, as the common terms imply, is manifested by an enlargement of the hock joint. As the condition progresses the joint flattens and the tendons slip to one side causing the shank to become twisted and the leg bowed.

Manganese is required in exceedingly small amounts—about 50 parts per million under average conditions. If bran and shorts are used liberally a deficiency is less likely; however, it has become quite a universal practice to add manganese sulphate to the mash at the rate of ¼ pound per ton of chick starter mash and ½ pound per ton of mash for layers and breeders. This is equivalent to approximately ¼ to ½ ounce per 100 pounds of mash.

Although a deficiency of manganese is undoubtedly the principal cause for perosis in young birds on practical rations, it is not the only factor involved. Recent research has demonstrated the lack of another factor, "choline," to be also concerned with this nutritional deficiency. Choline is not likely to be deficient in the ordinary well-balanced practical rations used in this region.

Minor Elements

Such minor elements as iodine, iron, and copper are needed in minute quantities. Iodine deficiencies have been demonstrated in certain areas of the goiter belt; however, there is no evidence that it is necessary to supply this mineral in poultry rations in Idaho. Many feed mixers, however, use iodized stock salt as a safeguard. In general there is a greater need for supplying supplementary iodine when calcite or limestone replaces the oyster shell and when the legume proteins replace the fish meals. Any of the marine products commonly used in poultry rations supply these minor elements to a greater extent than the average product produced from the soil.

Other minor elements appear to be adequately supplied in ordinary

feed mixtures used. There is no evidence to justify the necessity of supplementing the ration with so-called tonics, mineral mixtures, and so forth, when the mineral requirements are taken care of as previously discussed.

Grit

A hard insoluble grit such as granite or mica should be available in hoppers at all times. Grit seems to promote a more efficient utilization of feed and some experimental evidence indicates that it helps to prevent abnormalities of the gizzard lining.

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